RAPESEED OIL MEAL

STUDIES WITH

SWINE AND RATS

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RAPESEED OIL MEAL STUDIES WITH SWINE AND RATS

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ABSTRACT

Experiments designed to study the effects of Argentine type rapeseed oil meal as a protein supplement in swine rations, fed to experimental pigs and albino rats, were conducted.

Rations, calculated to contain similar levels of protein and varied in levels of rapeseed oil meal, were fed. Results obtained indicated that incorporation of rapeseed oil meal in the rations at a 10% level of the total ration reduced average daily gain and efficiency of feed utilization. Swine carcass characteristics, except for a slight tendency to be shorter on the 10% level of rapeseed oil meal, appeared to be unaffected.

In metabolism studies conducted with swine and rats, percents feed, nitrogen and energy digestibility were reduced on a 10% level of rapeseed oil meal. The nitrogen retention data were more variable. It was suggested that variations in thyroid response to the goitrogens present in rapeseed oil meal may have caused some of these variations.

Thyroid hypertrophy was evident in swine, and to a lesser degree in rats, as the percentage of rapeseed oil meal in the diet was increased.

In most instances a level of 2% rapeseed oil meal did not exert consistent deleterious effects upon normal body processes to the extent that the 10% level did.

Radioactive iodine studies on uptake of iodine by the thyroid tended to suggest a shorter biological iodine half-life in the thyrotoxic gland than in the normal gland in rats.

Higher quality foods reduced the thyroidal hypertrophy in the rat caused by feeding rapeseed oil meal containing foods.

Some indication was obtained that female rats responded to the growth depressants contained in rapeseed oil meal to a greater extent than males. Castration, especially in females, appeared to reduce the response to the inclusion of rapeseed oil meal in the food.

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RAPESEED OIL MEAL STUDIES WITH SWINE AND RATS

INTRODUCTION

The acreage sown to rapeseed in Western Canada has risen to an estimated one million acres during the current 1958 crop year and thus rapeseed has become the fifth cash crop on Prairie farms. Accelerating foreign and domestic demands for rapeseed oil have supplied the impetus for the dramatic production increase. A secondary effect of the rising production of rapeseed has been the increased supply and availability of rapeseed oil meal.[1]

The use of a locally produced vegetable protein supplement in Western Canada is very attractive to livestock men and offers the possibility of reducing feed costs. Currently ROM is a relatively inexpensive source of protein and could be widely used if it was acceptable as a supplement. At present its use by feed manufacturers is restricted by law in certain types of rations; for swine these are principally starter and breeder rations.

Recorded information on the usage of ROM for the various species of livestock is not too extensive. The goitrogenic effect of the members of the genus Brassica has been well established. Further evidence exists to show that although ROM is fairly high in digestibility, Morrison (1956) states 85% protein digestibility, it is not too palatable to livestock.

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[1] In the interests of brevity the term "ROM" is used subsequently to designate the byproduct obtained during the production of oil from various kinds of rape seed (Brassica napus L.).

Varietal differences within the plant itself, in addition to processing variations, add to the complexity of the problem.

In view of the economic importance of rapeseed production, not only to the livestock industry but to the plant growers and oil seed processors a definite need exists for further information concerning the use and limitations of this byproduct.

The trials reported in this thesis were initiated to study certain aspects of ROM usage in swine rations under Western Canadian conditions. The primary purpose of the work was to observe varying levels of ROM in rations and their effects on growing swine. The data were substantiated by inclusion of rat trials.

REVIEW OF LITERATURE

In his most recent edition Morrison (1956) stated that in Germany ROM has enjoyed long usage while Bell (1955) indicated that published experiments on the use of the meal appeared in 1872. Morrison added that "one must exercise caution in feeding rapeseed meal to livestock". Morrison further stated that rapeseed and its meal produces "irritating substances" in the digestive tract, is unpalatable due to its bitterness and is a goitrogenic substance.

Bell (1955) prepared an extensive review article concerning the nutritional status of ROM in which he states that the first report on the nutritive value of rapeseed appeared on this continent during 1944.

Presence of a Toxic Factor (or Factors)

Bell (1955) indicated that substances in rapeseed were isolated by early workers and proved to cause glandular disturbances in experimental animals. Pitt-Rivers (1950) suggested the presence of compounds in rapeseed that, upon oxidation, yielded thyrotoxic oxazolidone. In his review, Bell (1955) reported that prior to 1950 Petit and co-workers found that ROM inclusion in chick starters at a level of 20% resulted in considerable mortality. This review article presented further references which show that rapeseed meal causes:

(a) thyroidal hyperplasia

(b) growth disturbances

(c) appetite depression

(d) liver and kidney enlargements

(e) lactational disturbances in females.

Frolich (1953) stated that domestic animals could tolerate only limited amounts of rapeseed. He reported that the mustard oils and vinyl-thiooxazolidones contained therein were set free in the animals digestive tract. Bell (1955) stated that in 1949 both Astwood et al, and Carrol isolated a goitrogenic substance from Brassica seeds, including rapeseed, which was later proved to be 1-5-vinyl-2-thiooxazolidone and was synthesized in 1950. Axelrod (1955) added further evidence to associate the thyrotoxicity of ROM with the 1-5-vinyl-2-thiooxazolidone content.

There are some indications, such as Clandinin's[1](1958) observations, that location of seed production will affect the ROM thiooxozolidone contents. There is further evidence (Bell(1955)) that the cyanate content varies in species of rape.

Renner et al, (1955) noted that the Argentine type of rape exhibited a greater goitrogenic effect than did the Polish type. This is in contrast to Bell (1957) who reports no differences between Argentine and Polish types even though the former contained a higher level of goitrogen.

The glucosides sinigrin and gluconapin found in ROM were isolated by Matet et al (ref. Bell (1955)); these are known to be precursors of the goitrogenic isothiocyanates.

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[1] D. R. Clandinin - private communication.

Allen and Dow (1952) showed that the growth depressant in rapeseed was extractable and they later (Dow and Allen (1954)) concluded that the substance was a thiocyanate which tended to follow the meal and not the oil. Bell and Williams (1953) showed that ROM contained a water soluble growth depressant. Frolich (1953) also reported from Germany that these toxic[1] substances were water soluble and destroyed by dry heat at temperatures above 130°C.

Bell (1957) reports that hot water extraction reduced the growth depression resulting from ROM inclusion in mice diets. Clandinin[2] in contrast to these findings has reported that ether extracted rapeseed caused a marked increase in the goitrogen and growth depressing activity of the raw ROM.

Thomasson and Boldingh (1956) ascribed unfavourable growth rates of rapeseed oil to erucic acid - a long chain fatty acid. It is conceivable that in processing ROM some of this factor will remain within the meal itself, the actual amount of residual oil varying with the processing techniques used.

Bell (1955) has stated that Wetter and McConnel have found cyanate contents of ROM varying from 0.3 to 1.4% in solvent extracted meals.

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1. The term 'toxic' as used in this thesis means productive of various degrees of abnormality with respect to growth, thyroid size and/or its histology and several other disturbances of tissues or functions.

2 D. R. Clandinin - private communication.

Mode of Action of the Toxic Factor (or Factors)

Levitt (1954) states that in 1945 Greisbach and his co-workers in New Zealand, using rats fed on "the goitrogenic rapeseed", demonstrated an initial excess of thyroxine in the blood followed by a continued and diffuse epithelial thyroidal hyperplasia. With "vigorous stimulation", this was replaced by a thyrotrophic hormone excess and thyroxine insufficiency.

Allan and Dow (1952) reported young chicks exhibited thyroidal hyperplasia and accelerated body weight on diets containing 10 or 15% ROM.

Seed et al. (1953) estimated that the antithyroid drugs reduced the I^{131} (see footnote 1) biological half life in the thyroid gland by 50%. This is strongly indicative that goitrogens such as those contained in ROM interfere with normal thyroidal functioning. It must be borne in mind, however, that many other things may cause thyroidal changes. An iodine insufficiency is usually associated with goitre, however Axelrod et al. (1955) showed that some low iodine diets did not cause goitre. It has also been shown that excessive iodine will cause goitre (Greer and Degroot, 1956).

Greep (1954) proposed that a possible mode of thyroidal interference by the antithyroidal drugs is the blockage of protein iodination

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1 To facilitate usage the symbol I^* will be used to indicate I^{131}, the radioactive isotope of iodine with a half life of 8.3 days.

of amino acid derivatives in the gland. The increase in iodide content of the gland during such a medication substantiates this hypothesis. Wollman and Scow (1955), using I^*, showed that goitrogens blocked the iodine binding and resulted in an elevation of the thyroidal I^*: serum I^* ratio, which is indicative of such a blockage. Greer and Degroot (1956) also showed that iodine itself acted on the thyroid, inhibiting formation or release of the hormone and decreasing cellular activity.

Kratzer et al.(1954) reported that Protamone (an iodinated casein derivative with thyroidal secretion-like activity) reduced thyroid weight but not growth depression of chicks and poults. They observed no response from KI but achieved a positive lysine supplementation correlation. They concluded that rapeseed was a marginal source of lysine for these species. In contrast, Bell (1957) fed diets containing Argentine or Polish type ROM to mice, and found no benefits from various amino acid supplementations.

Bell and Baker (1957) and Bell (1957) have observed that Protamone or KI failed to counteract the effects of ROM as reported by Kratzers' group.

Clandinin[1] (1958) has found no goitrogenic effect of sinapin, the bitter substance found in ROM, yet noted a growth depression in chick studies.

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[1] D. R. Clandinin - private communication.

Pipes et al.(1958) have suggested an 8 to 14 day lapse for a goitrogenic effect to occur in euthyroid cattle. This tends to suggest the prevalence of a temporary delaying mechanism during goitrogenic reactions within the body such as effects of a hormonal cycle might produce. The ideas advanced by Taurog et al.(1958) that the pituitary regulates thyroidal iodine metabolism could suggest a possible reason for this delaying period. Premachandra et al.(1958) postulated that the pituitary controls: (a) growth of thyroidal cells and (b) glandular secretion and discharge, this lends further support to such an hypothesis.

In his review of the literature on this subject Bell (1955) postulates that perhaps the toxic factor(s) in ROM affect tissue oxidations and/or dehydrogenations. This in turn increases the demands placed upon the thyroid gland, which in turn is inhibited by the same toxic factor or other substances. This postulation would seem to allow for the many discrepancies that are reported in the literature.

Bell (1958) suggests the following possible methods of controlling the deliterious effects of ROM, namely:

(a) limitation of ROM intake,

(b) removal of the toxic factor(s) by extraction,

(c) antagonizing the factor - e.g. counteraction[1],

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[1] Bell (1955) reported Marine et al. have found antigoitrogenic substances in plants that exert thyroid sparing actions, probably by providing another mechanism for promoting tissue oxidations.

(d) use in species of animals showing the least adverse reactions,

(e) removal of toxic factors by plant breeding.

Nutritive Value of Rapeseed Oil Meal

Morrison (1956) reports the average analysis of ROM as 33 percent crude protein, 8.1 percent fat, 10.8 percent fiber and a protein digestibility coefficient of 85 percent while Bell (1955) reports an 82 to 86 percent range in protein digestibility. Reports in the literature, such as Thomasson and Baldengh (1956), that as the level of rapeseed in the diet of rats rose the growth rate was decreased, would suggest that the nutritional qualities of ROM are not parallel to its potential based on analysis.

Klain et al.(1956) have reported that as the percentage of ROM in the diet rose chick growth decreased with a parallel increase in goitrogen effects. They reported that the arginine levels in their sample of rapeseed appeared inadequate to meet the requirements of the chick. It is interesting to contrast the work of Fluckiger and Anderson (1957) with thiouracil in chick diets with the results of Klain's group. Fluckiger and Anderson found that when arginine was lowered in the diet thiouracil-fed chicks exhibited lowered thyrotoxic reactions. The work of Kratzer et al.(1954) showing lysine supplementation benefits, and the contrasting results obtained by Bell (1957) showing no beneficial effects of amino acid supplementation, during ROM feeding as reported on page 7 of this thesis should also be considered.

Gray (1957) has reported dry heat destruction of lysine in ROM. This dry heat caused an unexplained growth improvement in the Argentine variety. Clandinin[1] (1958) has also observed decreased levels of lysine in ROM due to heating effects encountered during the processing period.

Bell (1955) suggested that in ROM lysine may be limiting, supporting Kratzer and co-workers (1954) results. These latter workers reported that to achieve normal growth and development in chicks and poults the addition of lysine to a ROM supplemented ration was beneficial.

Dow and Allen (1954) reported that in a 19 percent protein ration for broilers ROM was a satisfactory substitute for soybean oil meal. The substitution of ROM in a high energy ration appeared to maintain optimum growth.

The contradictory results one may discover in the literature appear to create a confusing picture. The production of a uniform ROM sample would perhaps tend to alleviate these variations to some extent.

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1 D. R. Clandinin - private communication.

Variations in Response to Rapeseed Meal Feeding

The varietal differences exhibited by feeding Argentine, Turkish and Polish types of rapeseed has been noted (Bell(1955) , Clandinin (1958), Renner et al.(1955)).

Clandinin[1](1958) observed that supplemental feeding of iodine to laying hens failed to alleviate thyroid enlargement when the birds were fed ROM. Iodine supplement appeared to further intensify glandular hypertrophy. In contrast, this practice has been found beneficial in some species of animals by other workers (Kratzer et al. 1954).

Bell and Williams (1953) obtained deviating results when data obtained with mice fed ROM supplemented food were compared to reports in the literature dealing with other species of animals. They also reported the ineffectiveness of iodinated casein in controlling the effects of ROM usage at a 27 percent level when fed to mice, even though this had been reported to be effective for fowl and rats.

Allen and Dow (1952) reported that the degree of response to ROM varied with the breed of chick used. Premachandra et al.(1958) have reported selections of strains of New Hampshire chicks showing high and low response to a goitrogen.

Eskin and Bogdonone (1956) have reported sex as well as strain variations in response of rats when fed propylthiouracil. Females exhibited a greater response than males. Bell and Baker (1957) reported

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1 D. R. Clandinin - private communication.

species and sex differences in response to ROM feeding in mice. They found a greater response in female than in male mice. Levitt (1954) had reported previously on evidence in the literature that an interaction between thyroid and ovarian hormones exist. Premachandra et al.(1958) have found that I^* release from the thyroid gland in male chicks is slower than in females. Singh et al.(1956) have observed greater secretion of thyroxin in ewe lambs than wethers with the thyroxin secretion by ram lambs being between the two.

From reports in the literature, such as those mentioned above, it appears that the thyroid gland in the female of a species must meet demands greater than that necessary in the male. The euthyroid gland in the female appears to be nearer to an abnormal state due to these greater demands and an antithyroidal drug can more readily manifest its effects.

The report of Johnston et al.(1956) that thiouracil treated swine responded differently at temperature levels of 50° and 90°F supports the view that the effects of a thyroidal drug are increased as the activity of the thyroid gland rises with the decline in temperatures. At the 50°F level backfat depth decrease was correlated with ham protein increase. They found that the thyroid size differences in thiouracil treated animals, as compared to control animals, were greater at lowered temperatures. Rate of gain was greater on the goitrogen treated group at 50°F with no similar effect being noted at 90°F.

Bowland (1951) has reported that although thiouracil did appear to take effect more rapidly in the summer the overall results paralleled

those obtained from the winter group in swine trials. Bowland found decreased rate of gain in thiouracil treated animals, however the efficiency of feed utilization was greater in pigs fed thiouracil containing finisher rations, so long as this ration was not fed for too long a period. In some cases carcass quality was improved, loin area increased and carcass length decreased in thiouracil treated animals. Allen and Dow (1952) advocated the usage of ROM in poultry rations fed to chicks approaching market weight. Pipes et al.(1958) have recently suggested using goitrogens to cause a hypothyroidal condition in order to lower BMR rates in animals approaching the market finishing period.

The above literature review suggests that only broad recommendations can be made regarding the usage of feedstuffs containing goitrogens. The many variables, e.g., environment, sex, species, age, nutritive status of the animal, nutritional qualities of the ration and presence and/or removal of toxic factors, are but a few of the hurdles which must be overcome before making specific recommendations as to the usage of a feed such as ROM.

EXPERIMENTAL

OBJECTIVE

The trials were designed to study the rate of gain, efficiency of feed utilization and carcass characteristics of pigs fed rations containing Argentine type rapeseed oil meal; the energy and nitrogen digestibility and retention in pigs and rats receiving this meal; and the histology of the thyroid glands of pigs and the activity of the thyroid glands of rats fed rapeseed oil meal.

METHODS AND PROCEDURES

A. Formulation of Experimental Rations

The design of the experiment was to study the effects of Argentine ROM upon swine; therefore it was necessary to maintain as nearly identical rations as possible. It is an established procedure to alter the rations fed to the hog from weaning to market weight in order to meet its nutrient requirements and yet allow for the most economical production. For each growth stage, namely: starter, grower and finisher, the rations fed to the pigs were formulated to contain equivalent levels of protein. The Argentine ROM used in these trials contained 37.5% protein by analysis. It was added at the expense of the soybean oil meal and wheat (2.0 lb. ROM replaced 1.6 lb. soybean oil meal and 0.4 lb. wheat) to maintain these similar protein levels.

Table 1

Rations Used for Experimental Animals

Ration	Starter (S)	Grower (G)	Finisher (F)
Ingredients			
Wheat	73.45	25.0	25.0
Barley	0	47.0	36.9
Oats	0	10.0	25.0
Sucrose	10.0	0	0
Soybean oil meal	11.0	12.8	8.0
Fishmeal	4.0	2.0	2.0
Alfalfa meal (Dehydrated)	0	2.0	2.0
Iodized salt	0.50	0.50	0.50
Ground limestone	0.50	0.50	0.50
Zinc sulfate	0.05	0.05	0.05
Aurofac-10[1]	0.10	0.10	0.05
TM-10[2]	0.10	0.10	0.05
Vitamin mix No. 2[3]	0.20	0.05	0
Vitamin B_{12} supplement[3]	0.10	0	0
Dry vitamin A and D_2[3]	/	$\frac{1}{2}$ levels	$\frac{1}{2}$ levels
Argentine rapeseed oil meal[4]	...	...	...
Crude protein Av. %	18.4	16.9	14.2

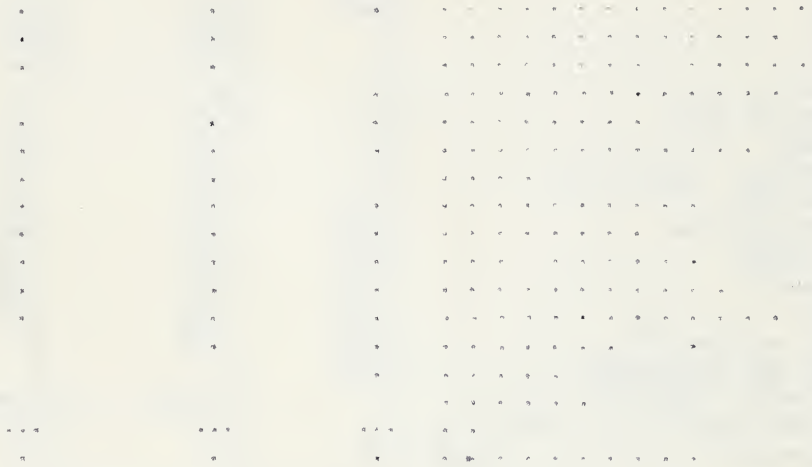
[1] Aurofac-10 containing 10 gm. chlortetracycline per pound.

[2] TM-10 containing 10 gm. oxytetracycline per pound.

[3] The supplemental vitamins supplied per cwt. of feed during the starting period were:

Vitamin A	50,000 I.U.
Vitamin D_2	10,000 I.U.
Niacin	1.8 gm.
Choline	2 gm.
Riboflavin	400 mg.
Pantothenic acid	800 mg.
Folic acid	12 mg.
Vitamin B_{12}	900 micrograms

[4] 2% ROM replaced 0.4% of wheat and 1.6% of SOM in basal for lots 2.
10% " " 2% " " " 8% " " " " " " " 3.



The composition of the various rations fed in these trials is presented in Table 1. The starting ration was fed to the pigs from the start of the period to an average weight of 35 lb., the growing ration from 35 to 110 lb., and the finishing ration from 110 lb. to market weight.

The experimental rats received identical feeds (foods) to those fed to the pigs. Unlike the pigs, the rats were allotted to a particular food, i.e. 2% Argentine ROM starter, and maintained throughout on this food.

The feeds were ground and mixed at the University Livestock Farm, bagged in approximately 100 lb. lots and stored in an unheated dry shed. Foods fed to the rats were further ground in the Wiley mill to pass a 20 mesh per inch screen to prevent sorting. The rat food supplies were kept in sealed glass jars in the rat room.

B. Methods and Procedures in Swine Experiments

1. Allotment

The allotment of the pigs in all experiments was as shown in Table 2.

Table 2

Allotment of Pigs in Rapeseed Oil Meal Experiments

Lot No.	Ration
1	Basal - no ROM
2	2% ROM
3	10% ROM

a. Group fed trials

Experiment 314 was initiated April 10, 1957 and continued to September 4, 1957. The average initial weight of the female and 2 males allotted to each lot was 14 pounds. The lots were balanced as to breed with two Lacombe-Yorkshire crossbreds and one Yorkshire pig in each lot. These animals averaged 24 days of age when placed on trial.

Experiment 314A was initiated April 24, 1957 and continued to October 3, 1957. The average initial weight of the 3 females and 2 males was 11 pounds. One Lacombe-Yorkshire and four Yorkshire pigs were included in each lot. These animals averaged 26 days of age when placed on experiment.

When Experiments 314 and 314A were combined, there were a total of 8 pigs, consisting of 4 of each sex, fed on each ration.

b. Individually fed trials

Experiment 314B was initiated June 16, 1957 and continued until November 21, 1957. The average initial weight of the 2 Tamworth Lacombe-Yorkshire male pigs allotted to each lot was 14 pounds. The animals were 21 days of age when placed on trial.

Experiment 314C was initiated August 18, 1957 and continued until February 5, 1958. The average initial weight of the 2 male pigs allotted to each lot was 13 pounds. A Yorkshire and a Lacombe-Yorkshire pig 21 and 20 days of age respectively were placed on experiment in each lot.

A total of 12 male pigs or 4 pigs on each of the 3 rations were fed in the individual feeding experiments.

2. Feeding Methods

a. Group fed trials

Animals in experiments 314 and 314A were group fed. Feed was available to the animals at all times from galvanized metal self feeders. The animals were housed inside on concrete floors. Animals in experiments 314 were housed in the old swine barn, while those in experiment 314A were located in the experimental wing of the new swine barn where the ambient air temperature was maintained at approximately 50°F.

In the old barn, experiment 314 hogs received their water from concrete troughs filled daily. In the new barn 314A animals were supplied with water from automatic watering bowls.

The pigs were weighed at weekly intervals and at this time group feed consumption data were recorded.

b. Individually fed trials

Swine in these trials were housed in the new barn in pens where they were fed individually but ran together in groups when not being fed. The animals were fed three times daily at 8 a.m., 12 p.m. and 5 p.m., being confined for a period of one hour at each feeding and allowed an amount that they would consume during that time.

Water was supplied in automatic watering bowls and was accessible to the animals when they were not confined in the feeding stalls. The pigs were weighed at weekly intervals and individual feed consumption data were recorded.

3. General Management

All pigs were marked at birth for identification purposes. They received the customary routine supplemental oral iron at twice weekly intervals from 3 days of age until they were weaned from their dams at 3 weeks of age. Male hogs were castrated at 4 to 6 weeks of age. They were wormed with a cadmium oxide compound for control of ascarids after allotment.

For the metabolism period conducted with the starter ration, the pigs in experiments 314B and 314C were transported to the University Research Laboratory and kept in the thermostatically heat controlled animal rooms at a temperature of approximately 70°F. The remaining two metabolism periods were conducted in the farrowing wing of the new swine barn. Further details regarding management during the metabolism periods are given in the following section. At the conclusion of these metabolism trials the animals were returned to the individual feeding pens described previously.

The animals were shipped to market at the first weekly weighing after they reached 190 lbs. liveweight. Following slaughter, Canadian Government carcass grades and Advanced Registry (National Bacon Hog Policy 1954) measurements and scores were obtained.

4. Metabolism Trials and Methods of Analysis

As these experiments involved the first time that the metabolism cages had been operated the actual pre-treatment and trial methods were somewhat varied; these modifications will be mentioned at the appropriate location.

Pigs weaned at this early age pass through a stage where scouring and vomiting may be prevalent. This period appears to be passed by the fourth week of age. Animals allotted to the higher level of ROM were the worst offenders in this respect. The addition of soluble Aureomycin[1] to the drinking water and placing a small quantity in the mouth of afflicted individuals usually cleared up this condition in a few days.

The animals were left on the farm for the first few days following weaning to become pacified and acclimatized to the ration. The pigs were then brought in the animal rooms where they were placed in the metabolism cages for an initial acclimatization period of about 3 to 5 days to allow the animals to become accustomed to close confinement and to learn to operate the feeding and drinking apparatus.

The details of the construction of the waterers, feeders and metabolism cages used for the 15 to 20 lb. starting pigs may be found in diagrams 1, 2 and figure 1. The equipment was designed in this laboratory by the author and a technician[2].

Feed was supplied ad libitum, being offered in the feeders shown in diagram 2. This type of feeder, attached to the front of the cage, was designed to prevent excessive wastage.

The waterer as shown in diagram 1 was designed with an overflow to conduct excess water away before it could contaminate the urine samples. The watering device was installed in the rear corner of the

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1 Aureomycin is a trademark for the antibiotic chlortetracycline.

2 The author wishes to acknowledge the valuable assistance of Mr. Cornelius Van Gorkum.

cage. Pressure from the city water main was reduced using a pressure regulator[1] and water was admitted by actuation of a pressure valve.[2]

The collecting trough, which may be noted at the base of the cage in figure 1, was attached to the bottom of the metabolism cage after a fine mesh copper wire screen had been inserted between the cage and the trough. The screen in the trough separated the excreta and the trough funneled the urine into 128 fl. oz. size glass jars placed beneath the trough. Each of these jars contained 50 ml. 50% H_2SO_4 to acidify and preserve the voided urine.

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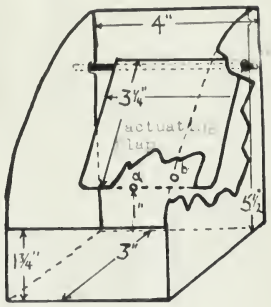
1 Model 7 Pressure regulator Mfg. by Helico Products Corporation, Santa Monica, California.

2 Hart Fount. Pat. No. 2307220. Mfg. by W.F. Hart Mfg. Co., Glendale, California.



a. overflow
b. inlet valve

Diagram 1. Design and Dimensions of a Metabolism Cage Automatic Waterer for the Young Pig

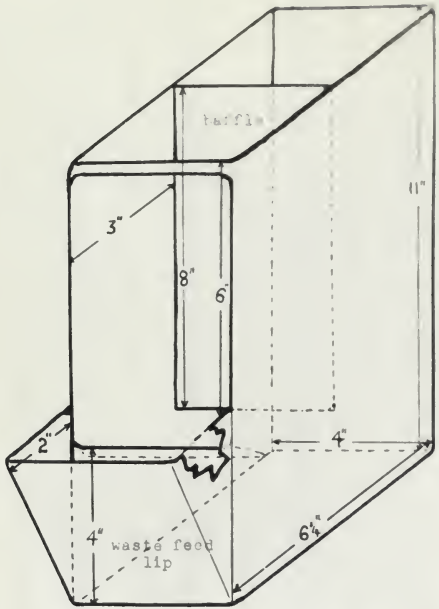


Diagram 2. Design and Dimensions of a Metabolism Cage Self Feeder for the Young Pig

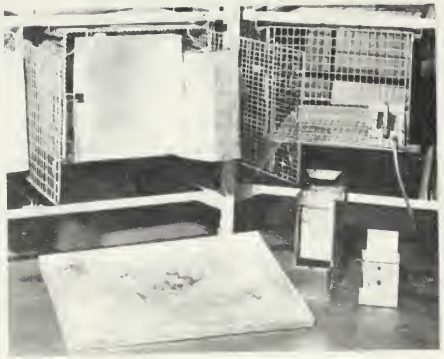


Figure 1. Illustration of the Metabolism Cage and Some of the Equipment used to Conduct Metabolism Trials on the Young Pig

For feces collection a swine harness described by Kolari et al. (1955) was modified as pictured in figure two. The modified metabolism harness, placed upon a 15 lb. pig is illustrated in figure three. The harness was designed for use upon male pigs only and a female animal as shown in figure three was used solely for illustrative purposes.

The use of Klikit type snap fasteners and detachable hose support grips made the metabolism harness adjustable. A leather collar (as shown attached to the two 7 inch straps pictured in figure 2) was used to hold a polyethylene bag which was attached over the rectum to collect the feces. It was found in some animals that this harness caused chaffing towards the end of the period. Rubbing the surface of the pigs' skin exposed to the harness with a weak solution of alcohol tended to alleviate this condition.

Fecal samples were collected daily. The feces were removed from the plastic bag as completely as possible and the feces and bag partially dried in a forced air oven at 75°C for sufficient time to allow complete removal of the feces. The bag was then cleaned of adhering matter and subsequently discarded. The oven temperature was raised to 105°C and samples were dried overnight. The oven-dried fecal samples were stored in closed glass bottles until completion of the experiment. The composite fecal samples from each pig were weighed and ground in a Wiley No. 1 Mill[1] to pass a 20 mesh per inch screen.

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[1] Wiley No. 1 Mill. Mfg. by A. H. Thomas Co., Phila., Pa.

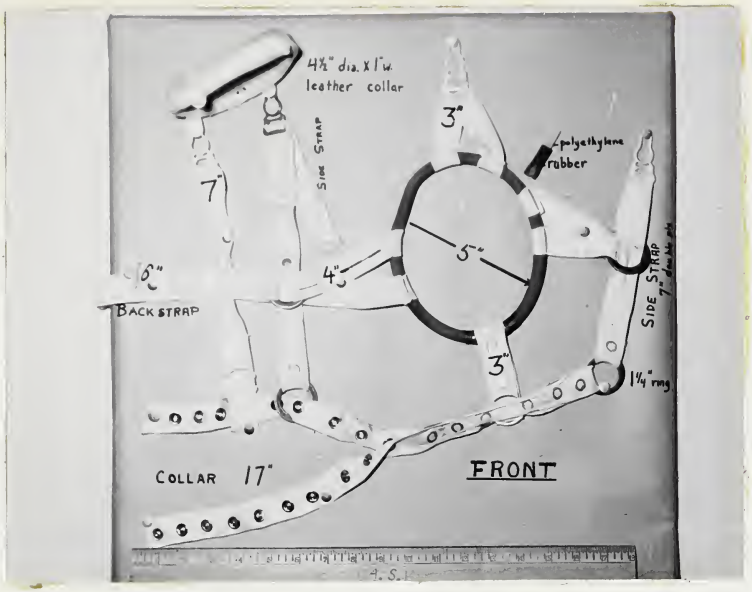

Figure 2. Illustration of the Adjustable Pig Metabolism Harness.

Figure 3. Illustration of a Young Pig Wearing the Adjustable Metabolism Harness.

An aliquot was drawn and put through a Weber Pulverizing Mill[1], to pass through a size 24 mesh per inch screen. The resulting sample was a very fine homogeneous mixture.

Acidified urine samples, containing cage washings, were allowed to settle. Total urine samples were weighed and aliquots were stored in ground glass stoppered bottles in the cold room at 38°F until analysis.

Feed wastage and water contamination in the metabolism cages presented a problem especially in the case of 2 individual pigs. In these cases the wasted feed was gathered, moisture content determined and reconverted to a dry feed basis and deducted from intake values.

The metabolism studies on the grower and finisher feeds were conducted on three animals simultaneously at approximately 50 and 140 pound stages. The metabolism crates used during these periods were constructed by Westeel Products Ltd., Winnipeg, Manitoba as specified in their drawing No's. 462-55-1 and 462-55-2. Three galvanized sheet metal sections each 19 inches wide, 40 inches long and 28 inches high were built onto a common frame as a complete unit. Hinged self feeders with approximately 40 lb. capacity and automatic waterers with 4 - 5 gallon capacity were also attached to the front of each of these individual sections. Certain modifications to this cage were found necessary, one being an adjustable feeder to cut down feed wastage.

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1 Weber Lab. Pulverizing Mill Mfg. by Weber Bros. Metal Works, Chicago, Ill.

In the starter trials a 7-day collection period was used. Animals in the metabolism trials using grower and finisher rations were on test for a 5-day period preceded by a 2 to 3 day cage acclimitization period. Prior to this stage they had been on the ration to be tested for at least 10 days.

In swine studies Lassiter et al.(1956) state that a 7 day period offers little advantage over a 3 day collection period when preceeded by a proper acclimitization period of 10 days. This concept was not tested in these trials but a 5-day collection period would appear to be adequate.

With the larger quantities in urine and fecal material from the growing and finishing hogs modifications were necessary in the methods previously mentioned for urine and fecal collection.

Urine samples were collected daily into large styrene plastic "diaper" buckets which held 10 liters of liquid. Urine was acidified by 75 ml. of 50% H_2SO_4 per bucket. Aliquot samples were usually taken daily in quart sealers after the weight in the styrene container had been determined. These aliquots were placed in the cold room at 38°F and the remaining urine was discarded. At the conclusion of the period the final weight of the urine and washings were computed and an equivalent of the total weight of each sample was combined. A convenient sample, by weight, was withdrawn from the combined sample and clarified. This known weight was made up to 500 ml. with distilled water and treated as previously outlined.

Fecal samples were collected daily. The animals were on screened floors with the feces usually dropping onto a tray below. Samples during warm weather were brought into the laboratory daily and dried as described previously. After the onset of winter, feces were stored in plastic bags in a cold room and the total 5-day sample dried at once. Attempts to take aliquots from fecal samples while in the undried stage did not prove successful so that entire samples were dried, weighed and ground as previously stated.

Nitrogen analysis of feeds, feces and urine for both the swine and rat studies were conducted via the Kjeldahl-Gunning method using boric acid to retain the ammonia. Fecal and feed samples from both the swine and rat experiments were analyzed in the Parr Oxygen Bomb Calorimeter[1], Anonymous (1948), to obtain caloric values. It was necessary to avoid pelleting some of the fecal samples in order to achieve complete combustion in the bomb.

5. Swine Thyroid Studies

Animals in experiments 314B and 314C were followed through the packing plant. Just prior to or upon reaching the eviscerating table the thyroid glands were removed. After the animals were killed by severing the juglar vein a 20 to 35 minute time lapse occurred before the glands were obtained.

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1 Parr Instrument Company, Moline, Ill., temperature changes recorded on a Brown Electronic Recorder manufactured by Minneapolis-Honeywell Regulator Company, Philadelphia, Pa.

a. Treatment of samples

Random portions measuring about $\frac{1}{4}$ inch square of the thyroid gland were immediately immersed in Bouins fluid[1] to fix the gland to prepare the tissue for microscopial study. The remaining portion of the gland was put into a small glass bottle and the gland in the 2 bottles was weighed on an analytical balance by weight difference.

The thyroid slices were left in the Bouins fluid for 24 to 48 hours at room temperature. After this time lapse the gland was removed, dried with a white absorbent paper and immersed in a 70% solution of ethanol where it remained until histological preparation.

b. Preparation of histological sections

The thyroid pieces were dehydrated by placing them through a series of 70, 85, 95% and absolute ethanol. Chloroform (xylol or turpenol may also be used) was used as a clearing agent. The dehydrated glands were put through three changes of wax. The slices were cut 10 microns thick using a microtome. The slices were treated to remove wax and were floated in water and removed by raising them out of the water on glass slides. The water was then evaporated leaving the dried tissue slices. These slides were then stained with hematoxalin and eosin. A cover slip was placed over the stained glandular tissue.

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1 Bouins fluid is a fixative composed of: 75 parts saturated solution of picric acid, 25 parts formaldehyde and 5 parts acetic acid, by volume.

c. Preparation of photomicrographs[1]

The thyroid gland slides were photomicrographed[2], developed and printed and examples are shown in figures 5a, 5b, and 5c, on pages 45, 45a and 45b.

d. General remarks

Unlike those of most other animals normal swine thyroids are unilobed. In most hogs, although exceptions appeared to be fairly common, the gland was located in front of the trachea or to one side near the location of the larnyx.

C. Methods and Procedures in Rat Experiments

Albino rats of the Sprague Dawley strain were obtained from the laboratory stock colony to be used for the following studies.

1. Metabolism Trials and Iodine Uptake Studies

a. Allotment

Rats used in these studies were weaned at 21 days of age and were allotted to 9 groups of 3 rats each as outlined in Table 3.

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1 The cooperation of Mr. S. Threlkeld, Graduate Student, Department of Plant Science is acknowledged.

2 A Zeiss Photomicroscope was used incorporating a 35 mm. camera Mfg. by Carl Zeiss, Oberkachen/Wurtt, Germany. A german film, ADOX KB14 ASA16, was used.

TABLE 3

Allotment of Rats in Metabolism Experiments

Ration No.	Ration	ROM %	Sex M	Sex F	Total Weight gm.
1S	Starter	0	2	1	141.2
1G	Grower	0	2	1	142.3
1F	Finisher	0	2	1	142.6
2S	Starter	2	2	1	141.8
2G	Grower	2	2	1	141.2
2F	Finisher	2	2	1	141.3
3S	Starter	10	2	1	142.5
3G	Grower	10	2	1	148.1
3F	Finisher	10	1	2	143.8

b. Feeding Methods

The method of handling rats during metabolism trials was similar to the method reported in Sibbald's (1957) thesis. The weanling rats were placed on a one week acclimitization followed by a one week metabolism trial. Individual feed records were kept for the animals.

Following the completion of these trials the same rats were continued on their respective foods with group food consumption records being kept until these rats were sacrificed during radioactive Iodine uptake studies.

c. Experimental Methods

I. Metabolism trials

(i) Confinement

After allotment the weanling rats were placed in Type LC-75/A[1]

[1] Manufactured by Geo. H. Wahmann Mfg. Co., Baltimore 2, M.D.

cages for acclimitization. Metabolism trials were conducted in type LC-176 metabolism cages, with type LC-278[1] Joy food cups being used to allow ad libitum food consumption. Prior to using the metabolism cages a 95% ethanol solution, saturated with boric acid was sprayed on the inner surfaces.

(ii) Collection of feces

Fecal samples during the metabolism period were collected daily and placed in small aluminum dishes, and oven dried overnight at 105°C. Samples were stored in screw cap glass jars and weighed at the termination of the experiment. Prior to analyses samples were ground to pass through a 20 mesh per inch screen in a small Wiley[2] mill.

(iii) Collection of urine

Urine samples were collected into 25 ml. of 50% by volume H_2SO_4. Samples and washings were filtered and made up to 500 ml. volume with distilled water and stored in the cold room at 38°F in ground glass stoppered bottles until analysis.

II. Iodine-131 studies

At the conclusion of the metabolism trials the animals were returned to the LC-75A cages and separated as to sex. After a total period of 148 days on trial they were utilized for I* uptake studies.

(i) Injections

A solution of 0.5 ml. of distilled water containing 75 microcuries

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1 Manufactured by Geo. H. Wahmann Mfg. Co., Baltimore 2, M.D.

2 Wiley Mill No. 4276 sold by A.H. Thomas Co. Philadelphia, U.S.A.

of a carrier-free sodium salt of I^* was injected intraperitonealy into each rat using a 1 ml. tuberculin syringe. The animals were sacrificed following a 10 hour overnight period.

(ii) Procedure for measuring I^* uptake and turnover rate

Animals were anesthetized by the use of chloroform. The thyroid gland was dissected out, cleansed of adhering tissues and placed in previously weighed ground glass stoppered weighing bottles. The weight of the thyroid was immediately obtained.

After weighing the gland was placed in a pyrex glass test tube and 2cc of 1 N NaOH was added. The tubes were placed into warm water to facilitate dissolving the glandular material.

Blood samples were drawn from the anesthetized rats by opening the chest cavity, puncturing the heart and collecting the blood using B-D Vacutainer 4" blood collecting tubes containing potassium oxalate. Blood samples were centrifuged, 1 ml. of serum obtained and the serum proteins, containing the so-called PBI (Protein Bound Iodine), were precipitated by using 10 ml. of 10% cold trichloroacetic acid. The precipitated serum was centrifuged in conical tubes and rewashed twice with 5 ml. of cold 5% trichloroacetic acid. After the last centrifuging the coagulum was redissolved by the use of 2 ml. 1 N NaOH and transferred to pyrex test tubes. Safety precautions recommended by Anonymous (1954) were followed in all phases of the radioactive work.

(iii) Counting techniques[1]

As most of the samples were "too hot" to count on the scintillator, aliquots were made. A Tracerlab Deca Scaler was used to record counts per minute obtained from a Scintillator which is a well-type gamma counter made by Atomic Instrument Company. With this type of counter it is possible to count samples contained in a liquid media held within a test tube.

2. Effect of Castration on Rapeseed Oil Meal Tolerance

(a) Allotment

Nine female rats weighing from 120 - 150 grams and 9 male rats weighing from 161-220 grams were selected from the stock colony which is fed a diet of Purina Fox Chow. Castrate males averaged 178 gm., control males 195.1 gm. ovariectomized females 138.4 gm. and control females 142.9 gm. respectively. The discrepancy in the weights of the male animals were due to operational losses which had to be replaced from diminished stocks.

These animals all received the Argentine 10% ROM grower ration for the experimental period.

(b) Feeding Methods

No food consumption data were recorded as the animals self fed from large hoppers and excessive wastage was often encountered.

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[1] The author wishes to acknowledge the use of the facilities of the McEachern Cancer Laboratory.

(c) Experimental Methods

Healthy rats were divided as to sex, weighed and marked for identification purposes.

I. Castration of animals

The animals assigned to be castrated were anesthetized with chloroform.

(i) Castration of males

The testicles were removed through two incisions in the scrotum. It was found essential to sew the wound together and reunite the skin by use of surgical clips. It is suggested that perhaps a better method of castration of males would be one incision into the abdominal cavity and removal of the testicles through this one opening. Males castrated the first way appeared prone to developing hernias. It was found necessary to tie off all severed cords with surgical thread to prevent hemorrhaging.

(ii) Castration of females

The abdomen had been shaved prior to anesthetizing and an incision was made, through the skin and muscular tissue, opening the abdominal cavity. The importance of fasting the animals prior to this operation should be emphasized. The two ovaries were removed with a small portion of the fallopian tube, which was tied and cut. The muscular abdominal wall was sutured with surgical thread and the skin sutured with surgical clips.

II. Analytical Techniques

Following weighing at the termination of the experiment, an overdose of chloroform was administered to each individual. Thyroid glands were excised and weighed. The liver, kidneys, lungs, heart and pancreas were removed and weighed. The moisture and protein contents of the liver and kidneys were determined as specified in the Official Methods of Analysis of the A.O.A.C.(1955).

RESULTS AND DISCUSSIONS

A. RESULTS AND DISCUSSION OF SWINE EXPERIMENTS

1. Metabolism Trials

Table 4 presents the data obtained from the metabolism trials conducted on swine receiving the various levels of ROM in their rations.

In view of the fact that these trials were the first ones conducted using the equipment unfamiliar operating techniques may have caused some variations in the initial phases of the first set of experimental results. It is the opinion of the author that the major errors and difficulties were overcome by the time the second phase of these trials, namely those conducted on the experiment 314C animals, were reached.

In the starter rations a 30% decline in feed consumption occurred on the 10% ROM ration when compared to the other two lots. During the following two periods the 2% ROM lot feed intake fell to a level similar to that of the 10% ROM lot with an average feed intake reduction of 10% below that of the basal lot. These observations agree with reports in the literature, Bowland (1957), and Morrison (1956) that ROM tends to be unpalatable to livestock. In the overall experimental period, however, as outlined in Table 5, no such effects on feed intake were noted.

Feed, nitrogen and energy digested (expressed as a percentage) were similar in the basal and 2% ROM lots; this has been interpreted to indicate that at the 2% ROM ration, only the feed intake had been affected.

Table 4

Ration Analysis and Metabolism[1] Data Relating to the Growing Pig

Ration[2]	Gross nitrogen	Gross energy	Weight gain		Feed Cons. O.D. basis	Feed digested	Nitrogen digested (ADN)	ADN retained	Energy digested (ADE)	ADE/kg. ABW
			Total	/kg. ABW						
	mg./100 gm.	Cal./100 gm.	kg.	gm.	kg.	%	%	%	%	Cal.
1S	2977	397	6.4	211	8.7	88	80	41	86	1053
2S	2946	396	6.7	222	8.7	88	85	39	87	1070
3S	2904	398	4.5	176	5.9	85	79	42	84	824
1G	2723	404	16.8	146	34.8	81	78	58	80	933
2G	2739	410	18.1	161	30.1	78	77	56	77	921
3G	2737	413	19.1	182	30.9	72	70	44	72	959
1F[3]	2458	407	11.8	97	31.0	81	82	47	81	831
2F[3]	2465	408	8.6	70	29.0	81	83	43	81	838
3F[3]	2376	404	9.1	87	29.0	78	80	53	76	891

[1]Seven day metabolism period for starter, five for grower and finisher.

[2]Key to ration numbers:

1 = 0% ROM S = starter
2 = 2% ROM G = grower
3 = 10% ROM F = finisher

[3]These averages based on two pigs.

Each replicate represents a total of 4 pigs or a total of 4 test per ration. Each hog was changed onto a ration as indicated previously, e.g. starter to grower and still held at the same level of ROM. (See footnote 3.)

In the 10% ROM lots there was a general declining trend present in the above mentioned digestibilities. The report of Morrison (1956) that, "upon digestion rapeseed meals tend to release, within the digestive tract, mustard oils that are irritating to the digestive tract", suggests that in these experiments at the 10% ROM level a sufficient quantity of toxic substances were released within the digestive tract to impair the digestion processes.

The ADN (Apparent Digestible Nitrogen) retention appeared to be variable within all groups and no definite trend was evident in these trials.

The ADE/kg. ABW (Apparent Digestible Energy per Kilogram Average Body Weight) data suggest that increasing ROM had no effect upon ADE intake, as based upon equal body weight, with one exception. It may be noted that a 20% reduction in ADE/kg ABW was evident during starter trials using 10% ROM. It is suggested that during this period either:

(1) Thyroxine synthesis surpression occurred with insufficient time for a compensatory thyroidal hypertrophy to occur, or,

(2) The effects of the male gonads, which were absent during the subsequent trials, may have been exerted in some manner. Reineke et al. (1948) stated that thyroidal secretion is at a maximum in the young pig and gradually declines as the animal ages. If this is true, then the thyroid gland subjected to a sudden goitrogenic stress, as was the case when these animals were placed on a 10% ROM ration immediately following weaning, needs a time lapse, as suggested by Pipes et al. (1958), before detectable glandular changes might occur. During this time the

endogenous thyroxine secretion may be reduced due to synthesis blockage and thereby result in a lower basal metabolic rate.

It is of interest to mention a more marked irritability and sensitivity of the pigs in the higher level ROM groups, especially during the starter periods, when compared to the basal or 2% ROM lots. It appeared as if these animals were more nervous, a condition observed in hyperthyroid humans.

A problem of hair contamination of fecal samples appeared to exist. Whiting and Bezeau (1957) have suggested clipping the animals. In the authors' viewpoint such a suggestion should be given consideration.

It appeared that removal of the animals from a controlled 3 times a day feeding system to a free choice method tended to increase feed consumption in the metabolism cages. The increased average daily weight gain during this period when compared to the pre and post trial period gains might have been due to the increased intestinal contents. It is felt by the author that in future metabolism trials the original feeding method should be adhered to during the metabolism procedures.

Barber et al. (1957) and Berg and Bowland (1958) have stated that restricted feeding in swine resulted in improved feed utilization over appetite fed hogs. This trend may be readily noted in this study when the group fed animals are contrasted to those in the individual trials; the question is how does this affect the metabolism studies.

Castle and Castle (1957) report that passage of food through the gut was lengthened in their trials by at least four hours by restriction of feed intake. They concluded that the alteration of rate of feed passage through the gut is a factor of quantity. Larger quantities of feed resulted in a more rapid flow of ingesta through the gastro-intestinal tract, consequently less absorption occurred. Reports such as Brandt and Thacker (1958) showing that feed passage through the gut is an exponential curve are accepted today.

With the many variables in the rate of passage of feed an improved method for fecal collection might be desirable. The use of an inert indicator in the feed such as chromic oxide, as suggested by Moore (1957) and Moore (1958) may be worthy of future investigation.

Summary

As the level of ROM in the ration was increased:

1. The total feed consumption during the period declined,
2. The feed, nitrogen and energy digestibilities declined at a level of 10% ROM in the ration,
3. The ADN retention appeared to be unaffected in these trials,
4. The ADE/kg. ABW appeared to be unaffected except during the starter period where 10% ROM in the ration caused a decline.

2. Rate of Gain, Feed Consumption and Feed Efficiency

Table 5 presents a compilation of the data from the swine feeding trials.

It was noted that as the level of ROM contained in the ration rose the age to market increased. An average difference of 20 days in age to market occurred between basal and 10% ROM fed animals. This is in agreement with observations such as have been noted by Reineke et al. (1948) and Bowland (1951) that inclusion of a goitrogen such as thiouracil in swine feeds retards rate of gain and maturation.

Feed consumption per pound of gain rose as the level of ROM in the ration was increased. The 2% ROM ration caused only a very slight increase in the feed consumption per pound of gain while the 10% ROM caused a 15 to 20% increase when contrasted to the basal ration.

The average daily feed intake remained relatively constant as the level of ROM was increased. This is in some respects contradictory to Bowland's (1957) report that in pre-starter rations palatability appeared to be a problem with higher levels of ROM. It appears that if the animals have no alternative choice they will eat ROM containing diets as their needs demand, at least up to the levels of 10% ROM, which was the highest level tested in these studies.

Table 5

Rate of Gain, Feed Consumption and Feed Efficiency of Swine
Fed Rapeseed Oil Meal Containing Rations

Experiment No.	314 and 314A			314B and 314C		
Method of Feeding	Group			Individual		
Lot No.	1	2	3	1	2	3
Ration	Basal	2% ROM	10% ROM	Basal	2% ROM	10% ROM
No. of pigs	8	8	8	4	4	4
Av. initial wt. ..... lb.	12.5	12.3	12.6	12.9	13.6	13.0
Av. final wt. ..... lb.	195.0	195.4	197.1	196.8	195.8	192.5
Av. age on test ..... days	26	26	26	21	21	21
Av. age to market .... days	149	154	166	166	170	182
Prestarter Period (13-35 lb.):						
Av. daily gain ..... lb.	0.72	0.65	0.64	0.56	0.56	0.44
Av. daily feed ..... lb.	1.46	1.38	1.52	1.26	1.27	1.18
Feed/cwt. gain ..... lb.	203	211	237	225	228	270
Growing Period (110-135 lb.):						
Av. daily gain ..... lb.	1.65	1.55	1.51	1.49	1.41	1.26
Av. daily feed ..... lb.	4.63	4.43	4.81	3.67	3.52	3.58
Feed/cwt. gain ..... lb.	281	285	319	247	251	284
Finishing Period (135-mkt.):						
Av. daily gain ..... lb.	1.86	1.80	1.62	1.59	1.50	1.45
Av. daily feed ..... lb.	6.85	6.90	6.71	5.51	5.74	5.84
Feed/cwt. gain ..... lb.	369	383	415	346	384	402
Overall Summary:						
Av. daily gain ..... lb.	1.49	1.43	1.32	1.28	1.22	1.12
Av. daily feed ..... lb.	4.63	4.65	4.66	3.73	3.81	3.83
Feed/cwt. gain ..... lb.	311	324	354	291	311	342
Grain ..... lb.	261	272	291	245	261	282
Supplement ..... lb.	50	52	63	46	50	60

Summary

It was noted in swine that as the level of ROM in the ration was increased:

1. The average daily gain was decreased and thus the age to market was increased,
2. The feed consumption per pound of gain was increased,
3. No definite changes in average daily feed intake occurred.

3. Carcass Quality

Table 6 presents carcass data obtained from the swine experiments.

Measurements by the criteria listed in Table 6 indicate negligible effects of ROM upon carcass quality. Bowland (1958) had previously observed that these pigs were quite variable as a group and no major trend was established in respect to carcass grades, dressing percentages and A.R. scores and measurements (National Bacon Hog Policy 1954).

In the 10% ROM fed lot the animals exhibited a slight tendency towards a shorter carcass length. This is contradictory to expectations since these animals were generally older when shipped to market and one would expect a longer carcass. Bowland (1951) has reported that thiouracil fed hogs had proportionately shorter carcasses than control animals. Reineke et al. (1948) suggest that differences in conformation in thyroprotein fed swine were due to an accelerated maturation change

Table 6

Carcass Quality of Swine in Rapeseed Oil Meal Studies

Ration	No. in lot	Av. hot carcass wt. lb.	Dressing %	Canadian Government carcass grades A	B_1	C	Av. carcass length in.	Av. fat shoulder, back & loin in.	Area of loin $in.^2$	Belly score max. 20	Av. A.R. Score M	F	Total
(1) Basal:													
Expt. 314 & 314A Group fed	8	154.4	79.2	1	5	2	30.3	1.63	3.07	9	40	51	48
Expt. 314B & 314C Individually fed	4	154.0	78.3	3	1	-	31.3	1.43	3.85	15	78	-	78
Av.		154.3	78.9				30.6	1.56	3.33	11	59	51	58
(2) 2% ROM:													
Group fed	8	153.1	78.4	5	3	-	30.5	1.48	3.32	13	59	69	64
Individually fed	4	155.0	79.2	4	-	-	31.1	1.42	3.73	17	80	-	80
Av.		153.7	78.6				30.7	1.46	3.46	14	70	69	69
(3) 10% ROM:													
Group fed	8	154.3	78.3	1	7	-	30.0	1.52	3.17	10	56	45	50
Individually fed	4	149.8	77.8	1	3	-	30.3	1.53	3.20	17	60	-	60
Av.		152.8	78.1				30.1	1.52	3.18	14	57	45	53

induced in these animals by increased thyroidal stimulation. They also stated that thiouracil tended to retard animals in growth. Such a growth retardation may be evidenced by a shorter carcass length. The 10% ROM ration used in these trials appeared to exert similar effects to those noted above.

As many of the carcass grades were borderline A's or B's the apparent superior grading in the 2% ROM animals probably indicates no real difference. Since some workers have advocated goitrogen usage in the finishing period to lower BMR by blocking thyroxine synthesis it may be that a 2% ROM ration, or perhaps a higher level of ROM, fed only during this period could prove beneficial due to the presence of a natural goitrogen in the finishing period feed.

Summary

As the level of ROM in the ration was increased:

1. No major effect on carcass quality was apparent in these trials,
2. It is suggested that the slight increase in carcass length in lot 3 was due to effects of the 10% ROM.

4. Thyroid Morphological Studies

The effects of Argentine ROM on the individually fed swine are presented in Table 7.

Figure 4 shows that as the levels of ROM fed to these swine were raised, a decreasing bodyweight to thyroid gland ratio occurred. There was a 10% decrease in this ratio in the 2% ROM lot and a 300% reduction

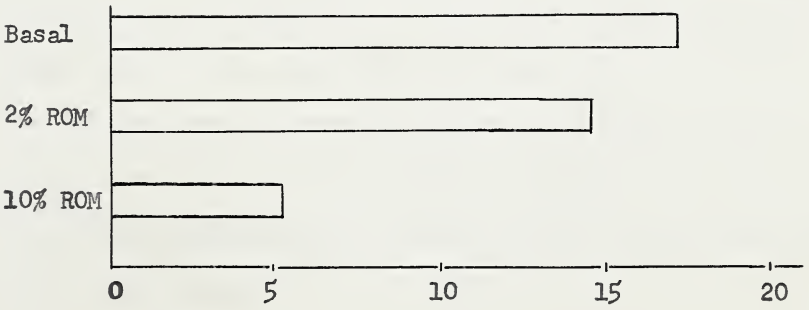
TABLE 7

Hypertrophic Influence of Rapeseed Oil Meal in the Ration on the Swine Thyroid

Ration	Pig Number	Age at Slaughter	Final Live Weight	Thyroid Weight	Body Wt(gm) / Thyroid Wt(mg)
		days	Lb.	gm	
1. Basal	254 M	165	191	9.3	9.3
	250 M	151	199	3.7	24.4
	337 M	170	205	5.2	17.9
	345 M	171	192	5.3	16.5
	Av.	164	198	5.9	17.0
2. 2% ROM	247 M	165	193	4.3	20.4
	253 M	165	192	5.5	15.8
	339 M	170	201	7.9	11.5
	343 M	177	197	8.6	10.3
	Av.	169	196	6.6	14.5
3. 10% ROM	248 M	165	190	20.8	4.1
	251 M	179	200	19.4	4.7
	340 M	192	201	16.3	5.6
	344 M	191	179	12.6	6.4
	Av.	182	193	17.3	5.2

FIGURE 4

Histogram Showing the Changing Body Weight to Thyroid Weight Ratio in Swine Fed Varying Levels of Rapeseed Oil Meal



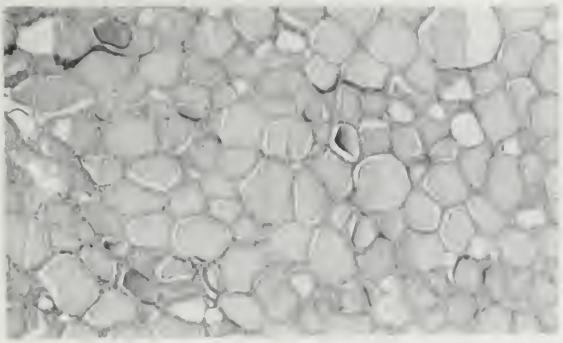
in the 10% ROM lot when the average values are compared to those obtained on the basal ration.

Photomicrographs of the thyroid glands of representative group 314C individually fed animals are presented in Figures 5a, 5b, and 5c. It is interesting to note that animal 344M was observed to be the slowest gaining one of the group, and eventually it was shipped to market at 179 lb. weight. It may be noted that the thyroid gland of this animal is somewhat smaller than that of its companion 340M, however, the glandular disturbances in this individual appeared to be the greater, in other words, in addition to a hypertrophic tendency, the gland also exhibited marked cellular disturbances and appeared to meet its demands by this method rather than by a severe hypertrophy.

According to Levitt (1954), in a thiouracil type of goiter iodine may enter the epithelial cells by either adsorption or selective incretion, however biosynthesis of organic iodide is prevented. This process produces insufficient thyroxine and an excessive level of thyrotrophic hormone. Levitt also states that thiouracil can reactivate the inactivated thyrotropin. This double action may then facilitate hyperplasia of the gland when associated with its diminished function. The ROM goitrogens appear to function in a manner similar to that reported for thiouracil by Levitt. A further discussion regarding the thyroid-ROM interaction is contained in the section involving I^* uptake studies with rats.

Figure 5a

Swine Thyroid Histological Photomicrographs
Experiment 314C
Basal Ration



Above:
Pig 345M. Age: 171 days
Thyroid wt. = 5.39 gm.

Below:
Pig 337M. Age: 170 days
Thyroid wt. = 5.20 gm.

[1] Circles represent relative size of magnified photo. scale: 1mm. diameter = 1 gm. wt.

In conclusion it may be stated that the histological studies as shown in Figures 5a, 5b, and 5c reveal that at the levels of ROM used, the gland appears to pass through the various stages of the pathological gland, namely: epithelial, lymphoid and fibrous tissues (Levitt, 1954). It appears that the lymphoid tissue increases as the hyper-active epithelial tissue wanes, and if the pathological process is continued, after reaching a peak the lymphoid tissue would then be replaced by fibrous tissue. The variations noted in response to a goitrogenic feed such as ROM may be due to the stage that the gland has reached in this "successive stage" idea propounded by Levitt. It is the opinion of the author, however, that one may not justifiably designate a thyroid as "diffuse epithelial hyperplastic" simply because a microscopic field that fits this description can be found. The contrast between 340M and 344M animals may often be encountered and differences in histology in various thyroid tissue slices obtained from a single animal may also be observed. In future studies it might be desirable to stain the thyroid slices with one of the stains that indicate, as Greep (1954) suggested, the state of colloid activity.

Summary

As the level of ROM in the ration was increased:

1. (a) At the 2% ROM level the mean thyroid gland weights indicate only slight, if any, thyroid hypertrophy,

   (b) At the 10% ROM level the mean thyroid gland weights indicate a 300% increase in thyroid weight or a definite hypertrophy,

2. Histological variations appeared to occur within the gland and some hyperplasia was evident.

B. Result and Discussion of Rat Experiments

1. Metabolism Trials

Tables 8a and 8b present the data obtained from the metabolism trials conducted with the rats receiving the various ROM containing rations. A statistical analysis was conducted by analysis of variance, using the "F" test (Johnson, 1950). To facilitate discussion of the results of this analysis the following designations were chosen: ration (R) has been designated for levels of ROM whether 0, 2 or 10%, treatment (T) has been used for differentiating between starter, grower and finisher, interaction has been designated as RXT, it may be regarded as the effect of treatment on constant levels of ROM or vice versa, sex (S) has been designated as a means of comparing differences between male and female rats.

The analysis disclosed that during the "first" trial: weight gain, gain per 100 gm. ABW, oven dry food intake, % ADN retention (with the exception of a statistically significant effect of treatment) and ADE were not altered by ROM in the diet. Significant differences were observed in the first "trial" period on:

(1) Percent food digested; ration, treatment and sex differences were highly significant, no interaction was evident.

(2) Percent ADN; ration and treatment effects were highly significant and interaction of RXT was also significant.

Table 8a

Food Analysis and Weight Gain of the Growing Rat[1]

ROM	Ration No.	Food Analysis		Weight Gain	
		Gross nitrogen	Gross energy	Total	/100 gm. ABW
%		mg./100 gm.	Cal./100 gm.	gm.	gm.
0	1S	2977	397	94.3	98.5
	1Sa			111.6	69.8
0	1G	2723	404	108.3	114.1
	1Ga			80.1	53.4
0	1F	2458	407	100.4	108.4
	1Fa			94.1	64.6
2	2S	2946	396	88.8	95.2
	2Sa			73.3	47.1
2	2G	2739	410	82.5	94.4
	2Ga			43.8	30.6
2	2F	2465	408	86.1	96.7
	2Fa			120.8	79.7
10	3S	2904	398	90.7	101.1
	3Sa			81.6	54.9
10	3G	2737	413	86.8	99.1
	3Ga			75.9	46.5
10	3F	2376	404	46.7	58.6
	3Fa			54.2	52.0

[1]Each replicate represents the data from three rats or a total of six tests per ration. The letter a designates the second replicate conducted one week after the first replicate.

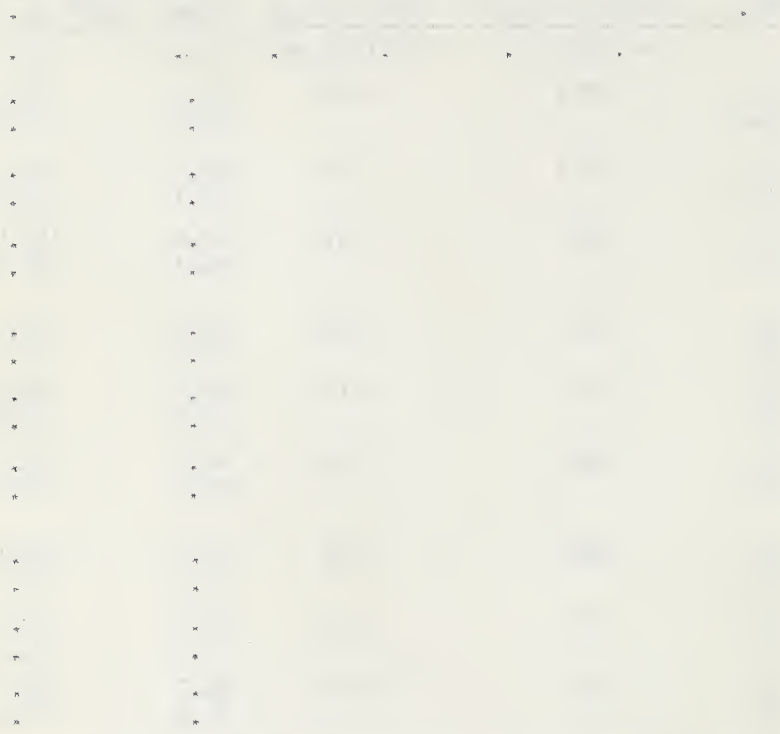


Table 8b

Metabolism Data Relating to the Growing Rat

Ration No.	Food Cons. O.D. basis	Food digestibility	Nitrogen digested (ADN)	ADN retained	Energy digested (ADE)	ADE/100 gm. ABW
	gm.	%	%	%	%	Cal.
1S	83.2	86.1	82.2	56.2	85.3	314.2
1Sa	99.7	86.4	84.1	38.6	85.8	230.5
Av.		86.3	83.2		85.6	
1G	96.3	78.7	78.9	59.8	79.1	339.5
1Ga	101.6	78.7	81.4	41.6	78.9	236.2
Av.		78.7	80.2		79.0	
1F	91.6	77.9	80.4	60.4	78.5	309.0
1Fa	99.6	74.8	75.1	48.7	75.3	227.3
Av.		76.4	77.8		76.9	
2S	79.7	86.7	83.5	50.3	86.3	311.1
2Sa	78.6	84.6	83.3	27.6	83.7	213.0
Av.		85.6	83.4		85.0	
2G	79.7	78.7	76.9	53.7	79.5	308.9
2Ga	83.8	78.3	78.2	36.6	78.4	207.6
Av.		78.5	77.6		79.0	
2F	84.0	78.1	82.0	56.4	78.7	325.8
2Fa	116.8	76.7	78.3	47.1	76.8	266.5
Av.		77.4	80.2		77.7	
3S	82.4	84.2	79.1	52.1	83.8	300.6
3Sa	89.9	83.3	80.2	30.9	82.4	214.6
Av.		83.8	79.6		83.1	
3G	84.0	77.7	75.9	54.5	78.4	329.9
3Ga	91.9	76.1	75.2	24.8	76.9	221.6
Av.		76.9	75.6		77.6	
3F	60.7	74.8	72.2	38.3	74.7	274.4
3Fa	79.4	69.7	69.4	33.8	70.4	219.7
Av.		72.4	70.8		72.6	

(3) Percent ADE; ration, treatment, sex and RXT were all highly significant.

During this first period statistically significant digestibility differences between ration, sex and treatment are apparent. In most instances the 2% ROM ration is equal to the basal, and the 10% ROM ration is inferior.

Analyzing the data for the second trial designated by "a" in Tables 8a and 8b disclosed that during this period - after the rats had been fed ROM for an additional 2 weeks no significant differences were noted in:

(1) Percent ADN retained, except in sex, where the males increased ADN retention at a highly significant level in contrast to the females. It appears that females reacted more unfavourably to the ROM in the diet;

(2) ROM and ADE/100 gm. ABW.

The above 2 cases are in agreement with trials conducted previously.

The second trial period disclosed the following statistical differences:

(1) Total weight gain was influenced by ration, treatment, sex and RXT interaction. The inclusion of ROM in rations of female rats appeared to cause a reduced rate of gain. Adjusting the gains to a 100 gm.ABW basis still showed a significant effect of ration and sex with the same effects of ROM and female inclusion as before.

The interaction of RXT on gain per 100 gm. ABW indicated a non-significant difference in contrast to the total gain,

(2) Oven dry basis food consumption was highly significantly affected by sex and RXT interaction. This reduction in female food intake can be usually expected. The RXT interaction effect tends to support the idea that ROM inclusion in a higher quality diet appears to exert a less deleterious effect,

(3) Percent total food, nitrogen and energy digestion were all highly significantly influenced by ROM, treatment, sex and RXT interaction. The complex relationships involving these factors render it difficult to offer a comprehensive explanation.

The data obtained from these two trials suggest that:

(1) Females reacted more unfavourably to ROM than males,

(2) As ROM in the diet was increased, food, nitrogen and energy digestion was decreased,

(3) The inclusion of higher protein and energy feeds rendered the growth depressing effects of ROM less pronounced. It is interesting to compare this to results reported by March and Beily (1957) that chicks receiving thiouracil on a high fat ration, containing levels of fat over 10% when compared to birds receiving only a 2% level of fat exhibited lower thyroid weights. The growth and digestibility results suggest that for the rat ROM is not a satisfactory replacement for soybean oil meal. It is not known if this is due to nutritional imbalances such as have been suggested in some literature or some other factor(s),

(4) Some factors did not appear to be influenced by ROM in these trials, for example percent ADN and ADE/100 gm. ABW. This is strongly indicative that 10% ROM did not interfere to a marked degree with body processes of the rats during the time period covered by these trials even though digestibility of the ROM containing foods were lowered,

(5) The apparent time lapse for ROM to take effect on some of the criteria reported suggests a delaying mechanism. Such a time lapse may be required for a substance to become depleted, as for example thyroxine, within the body.

Summary

As the level of ROM in the foods fed to the growing rat were increased:

(1) Total food consumption and total weight gain declined only with the 6 to 7 week rats as compared to the 4 to 5 week old rats,

(2) Food, nitrogen and energy digestibilities showed highly significant reductions,

(3) Percent ADN and ADE/100 gm. ABW appeared to be unchanged,

(4) Female rats appeared to exhibit greater susceptibility to ROM toxicity than males,

(5) The reduced toxicity of ROM in the starter ration when compared to the grower and finisher rations suggests a possible nutritional inadequacy or imbalance,

(6) It is suggested that a time lapse occurs before ROM exerts its toxicity and possibly this toxicity progresses as the feeding is prolonged.

2. I-131 Uptake Studies

a. Five Month Feeding Trial

Table 9 presents the 148 day food consumption and gain of the 27 rats which were used initially on the previously mentioned metabolism trials.

The 2% ROM diet resulted in equal or superior gains to those obtained on the basal diet which in turn was superior to the 10% ROM containing diet. Total food consumption appeared to vary among types of rations and levels of ROM but no consistent results were noted.

The overall trend of inferior results with the 10% ROM and varying results with the 2% ROM diets fed to the rats for a prolonged period is in general agreement with the tendencies noted in the swine trials.

Summary

As the level of ROM in the ration was increased:

(1) Total weight gain and food consumption in the 10% ROM lot was reduced below the basal and 2% ROM lots,

(2) Efficiency of food utilization was adversely effected by the addition of ROM only on the starter rations when compared within treatments.

Table 9

Five Month Total Food Intake and Gain of Rats Fed Rapeseed Oil Meal Containing Rations

Ration No.	% ROM fed	No. of rats	Total weaning weight	Total final weight	Total weight gain	Total food consumed	Gm. food per gm. gain
			gm.	gm.	gm.	gm.	
1S	0%	2M, 1F	140.1	987.1	846.0	5843	6.91
1G	0%	2M, 1F	142.3	928.4	786.1	7688	9.78
1F	0%	2M, 1F	144.1	938.4	794.3	7581	9.54
	Total				2326.4	21112	
2S	2%	2M, 1F	139.7	960.0	820.3	7200	8.78
2G	2%	2M, 1F	141.2	1007.5	870.8	7866	9.03
2F	2%	2M, 1F	141.4	940.7	799.3	6129	7.67
	Total				2490.4	21195	
3S	10%	2M, 1F	144.6	877.0	732.4	7161	9.78
3G	10%	2M, 1F	143.1	992.0	765.9	7533	9.84
3F	10%	1M, 2F	142.3	741.5	599.6	5570	9.30
	Total				2097.9	20264	

b. I-131 Studies

Table 10 and Figures 6 and 7 present the results obtained in the I^* studies on the rats used previously in the metabolism studies. Tables 11a and 11b present the results of a statistical analysis conducted on some of these results.

If we examine the ratio of body size and thyroid size as presented in the above mentioned tables and figures it is evident that the treatment has resulted in a highly significant effect. Further analysis reveals that this ratio was also influenced to the same extent by sex differences, females exhibiting a more hypertrophic gland.

Hevesy (1948) states that the use of radioiodine as an indicator has greatly enlarged our knowledge of relationships of thyroid gland activity. Hevesy reports that radioiodine secretion from the thyroid has been observed within 2 hours from I^* injected rats. To measure thyroid activity and follow the toxicity of ROM on the thyroid it was decided to use the T/S ratio. The numerator T, represents the radiological activity of 1 gram of thyroid tissue. The "T" value incorporates iodine that has been trapped by the thyroid and within the gland, be it in the inorganic or organic form. It is a value denoting overall thyroid radioiodine content. The "S", or denominator in the T/S ratio in this work is the activity from 1 ml. of serum that has been treated in a manner previously described. This is the fraction of radioiodine that has passed through the thyroid gland and is in the organic form or PBI fraction of the serum. Ershoff and Golub (1951) indicated the value of PBI in measuring thyroxine levels in the blood. The use of the

Table 10

Effect of Ration Type and Rapeseed Oil Meal Level Variations on I-131 Ten Hour Period Uptake and Turnover Rates in Experimental Rats[1]

Ration No.	% ROM Fed	Av. wt. of thyroid	Av. wt. of thyroid per kg. body wt.	(S) = Av. count/min. of 1 ml. serum	(T) = Total thyroid count/min.	% (T) of standard[2]	Av. T/S ratio	Av. body wt. gm. / thyroid wt. gm.
		mg.	mg.					
1S	0%	16.1	52.7	10,660	451,200	11.2	43.0	20.8
1G	0%	19.3	65.3	13,360	625,800	13.6	43.9	16.1
1F	0%	18.0	56.1	15,230	627,700	15.6	41.5	20.5
2S	2%	16.6	52.6	11,230	369,000	8.5	32.8	19.0
2G	2%	17.3	54.3	9,073	516,600	12.9	55.6	18.4
2F	2%	22.7	73.7	9,530	387,400	9.6	40.6	13.6
3S	10%	14.9	51.3	12,810	256,100	5.9	20.0	19.8
3G	10%	20.3	68.3	13,330	466,800	10.7	36.3	14.6
3F	10%	20.8	86.4	12,800	311,100	7.8	24.6	11.8

[1] Three rats per group as listed in Table 3.

[2] Standard = 75 microcuries I-131. Background = 497 c/m

FIGURE 6. RATION EFFECTS ON RAT THYROID W.T.

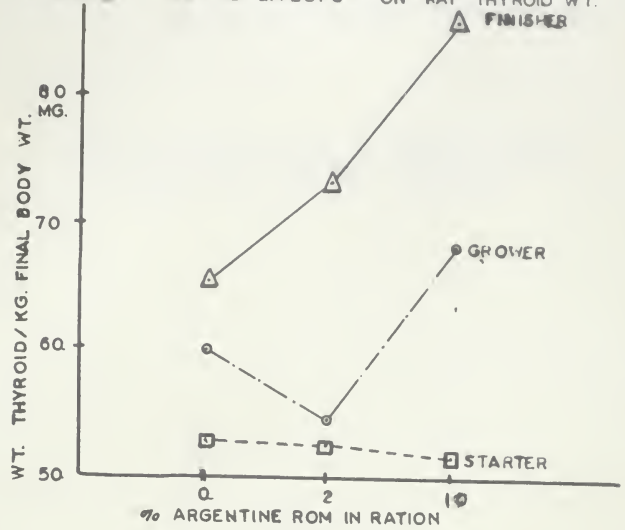
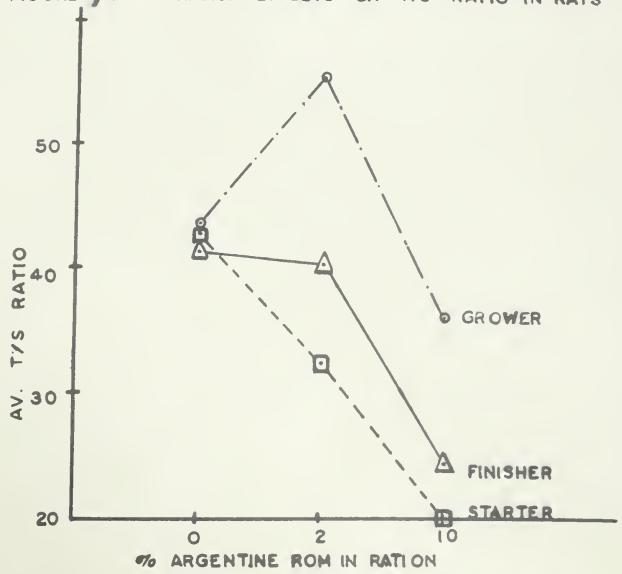


FIGURE 7. RATION EFFECTS ON T/S RATIO IN RATS[1].



1. T/S RATIO= $\frac{\text{TOTAL THYROIDAL RADIOACTIVITY./GM.}}{\text{TOTAL RADIOACTIVITY OF PROTEINACEOUS PPT./ML. SERUM.}}$

T/S ratio has been in use for some time. Taurog et al. (1958) have recently used the T/S ratio as:

$$\frac{\text{Total I-131 per gram of thyroid tissue}}{\text{Total I-131 per ml. of plasma}}$$

TABLE 11a

Analysis of Variance as Applied to T/S Ratio

	df	Sum of Squares	Mean Square	F
Total	26	3,483.64		
Ration	2	855.54	427.77	11.93**
Treatment	2	1,514.92	757.46	21.13**
Sex	1	122.09	122.09	3.41 n.s
RXT	4	381.71	95.43	2.66 n.s.
Error	17	609.38	38.58	

TABLE 11b

Analysis of Variance as Applied to Body Wt/Thyroid Wt. Ratio

	df	Sum of Squares	Mean Square	F
Total	26	504.48		
Ration	2	102.57	51.28	8.23**
Treatment	2	63.11	31.86	5.07**
Sex	1	145.10	145.10	23.29**
RXT	4	87.85	29.96	3.52*
Error	17	105.85	6.23	

** highly significant - probability at the 1% level

* significant - probability at the 5% level

n.s not significant

An examination of the total thyroid count (T) as shown in Table 10, and the percent of the standard (which was 75 microcuries of carrier free I^*) indicates that as the level of ROM rose the percent T appeared to decline, indicating either a reduced uptake or a more rapid turnover. Analysis of variance as presented in Table 11a has shown that ration and treatment caused highly significant changes in this ratio. As the level of ROM in the ration rose the T/S ratio declined and the treatments caused further variation to occur. There appeared to be a more rapid decline in the "T" value than in the "S" value; this could perhaps be attributed to:

(1) Greater gland size and hence faster $I_{org.}$ secretion, as suggested by Greep (1954).

(2) Blockage of I^* uptake, as Greep suggests, however it is felt that if this were the case then it would appear logical to expect a parallel drop in "S" values (such a tendency may be noted in the 2% grower and finisher consuming rats).

(3) Secretion of one or more of the intermediary inactive products that might result from a blockage of a biological process contained in the thyroid gland and perhaps an effect on the excretion rate of this intermediary. It should be recalled, however, that Levitt (1954) has stated that iodine uptake is independent of iodine secretion.

To test these hypothesis, especially the 3rd point, further work appears to be essential.

Joftes (1958) has noted that in mice I^* injections caused wide variations in rate of uptake, stating that the PBI values tended to exhibit wide variations. Joftes concluded that even combined uptake and PBI ratio studies are not dependable criteria to measure thyroid damage. He has suggested measurement of endogenous TSH as a more suitable criterion. This view is also supported by Premachandra et al. (1958). In view of these recent findings, a series of studies to follow thyroxine secretion would be indicated in order to clarify the trend noted in these trials. The actual period of time of analysis after injection of I^* is also open to debate. Johnson and Albert (1951) found about 1/3 of I^* was excreted into the urine in rats after a 12 hour lapse. Taurog and Chaikoff (1948) reported that in 24 hours 90% of the inorganic iodine had been converted to the organic form by the thyroid. Wolff (1951) reported a 90% uptake of I^*in 12 hours in rats following an I^* intraperitoneal injection. Hevesy (1948) reported that Chaikoff and his associates observed that within 2 hours following injection, from 1.5 to 3% of a tracer dose of I^* was retained as thyroxine in the rat thyroid gland which ranged in weight from 11 to 22 mgm.

Mosier et al. (1958) have observed that the normal mechanism to carry iodine to the organic form and deiodination of free iodotyrosine in human cretins is blocked with an almost complete failure to form iodothyronine derivatives. They point out that the normal thyroid mechanism is unknown. It may be a similar blockage of enzyme systems that Mosier et al. suggest that occurs in ROM feeding. Taurog et al. (1958) state no mono or diiodotyrosine was found in normal horse and

sheep blood samples. It would be of interest to see if these compounds occur in individuals made thyrotoxic by ROM or whether inorganic iodine is resecreted. The possibility of this latter type of iodine re-excretion by the thyroid gland is unlikely since Greer and Degroot (1956) have observed that iodine inactivates TSH and blocks its secretion; and in contrast, Levitt (1954) reported that in rapeseed induced goiter a TSH excess occurs. Levitt (1954) reported that a flouride derivative acetyl-amine flourine enhanced the effect of rapeseed TSH excess. This may suggest that some enzymatic blockage exists, since flourine is a known enzyme inhibitor and furthermore is a halogen and probably capable of entering the thyroid and when within the gland it would be in a position to accelerate further enzymic blockage.

The report of Fraser in Eckstein & Zuckerman (1953), that in humans the prolonged administration of a goitrogen depletes the body iodine stores and results in a gland with an accelerated affinity for I does not appear to be the case in these trials.

The reports in the literature tend to suggest that one must use caution in interpreting the results in the above experiment; however an indication exists that some abnormality is occurring in the gland.

Since these trials produced interesting results the use of different techniques as suggested by Joftes (1958), and larger numbers of animals appear to be indicated.

Summary

As the level of ROM was increased:

(1) There was an effect on the gross thyroid as shown by the body weight to thyroid weight ratio decline,

(2) There was evidence of some biological disturbances occurring in the thyroid gland.

3. Effect of Castration on Rapeseed Oil Meal Tolerance

The results obtained in this phase of the experiment using 46 day old Sprague - Dawley rats placed on 10% Argentine ROM grower ration for a 95 day period are shown in Table 12.

From the data presented in the aforementioned table the following may be indicated:

(a) Males versus females

(1) Weight gain differences in favor of males,

(2) The average liver and kidney dry matter in males was lower by at least 10 percent,

(3) Lungs of males weighed less with the normal male lung adjusted to one kg. final weight weighing the least,

(4) Almost a twofold increase in Mg $N/_{gm}$ on a dry matter basis in male kidney and liver tissues.

(b) Castrates versus normals

(1) Reduction in internal organ weights in castrated animals; of interest here was the reduction in thyroid weight by over 10 percent,

(2) A marked increase in weight gain of castrated females.

Table 12

Effect of Castration on Rapeseed Oil Meal Tolerance in Rats[1,2]

	Females		Males	
	Castrate	Normal	Castrate	Normal
No. of rats	5	4	5	4
Initial wt. gm.	138.4	142.9	178.0	195.1
Final wt. gm.	241.9	206.7	300.5	332.1
Total 3 mo. gain gm.	103.5	63.8	122.5	137.0
Gain per kg. av. wt. gm.	428	307	408	413
Internal Organs				
Total weight:				
Testicles gm.	-	-	-	8.3
Pancreas gm.	0.66	0.61	0.73	0.71
Heart gm.	.84	.82	1.05	1.22
Thyroid mg.	18.2	17.6	28.1	31.2
Lungs gm.	1.62	1.44	1.92	1.72
Organ weight per kg.:				
Pancreas gm.	2.7	3.0	2.4	2.1
Heart gm.	3.5	4.0	3.5	3.7
Thyroid mg.	74.1	85.1	77.1	93.6
Lungs gm.	6.7	7.0	6.4	5.2
Liver:				
Total wt. gm.	9.30	8.99	12.40	14.36
Wt. per kg. gm.	38.5	43.5	41.3	43.3
Mg N/gm. mg.	34.0	33.2	30.6	30.8
Mg N/gm. D.M. mg.	127	125	211	220
Moisture %	73	73	85	86
Kidney:				
Total wt. gm.	1.67	1.57	2.00	2.44
Wt. per kg. gm.	6.9	7.6	6.7	7.4
Mg N/gm. mg.	32.2	32.4	21.9	32.9
Mg N/gm. D.M. mg.	121	122	233	247
Moisture %	73	66	86	87

[1]All rats were fed swine grower ration containing 10% rapeseed oil meal.

[2]Internal organ weight per kg. is based on per kg. final body weight.

It appears evident that both sex and castration exerted some effects on ROM tolerance in the animals used in these trials. Castration tended to reduce the greater sensitivity of females to ROM.

Levitt (1954) indicates the importance of the sexual cycles upon the various endocrine glands. Mention is made of McGavack's work showing that castration leads to involution (degeneration) in the thyroid gland and a slight fall in BMR. McGavack noted small physiological doses of androgens and estrogens stimulated thyroid activity, while large doses reduced it. Ganong and Junker (1955) reported depressed thyroid activity in the castrate dog. These workers found contradictory evidence in the literature stating that castrate female rats had an I^* uptake similar to normal females. Feldman (1956) noted that estrogen administration to male castrate rats significantly enhanced iodine trapping. Kochain and Evans (1956) reported no difference in I^* uptake by castrate or normal rats receiving an exogenous testosterone supply.

The report of Singh et al. (1956) regarding reduced thyroxine secretions in wether lambs and to a lesser degree a reduced thyroxine secretion of rams in comparison to ewes tends to suggest, as previously stated, a more active gland in females and a further reduction of thyroxine synthesis by castrated males. This trend in normal animals might have been due to the involution effects on the thyroid mentioned by Levitt (1954). In the rat trials reported here a similar trend is apparent.

Common et al. (1955) had noted that combined estrogen-androgen treatment of immature pullets subjected to thyroxine or thiouracil exhibited various organ changes. The liver and kidneys of the birds were affected in dry matter as well as crude protein contents with thiouracil treatment enhancing the weight and protein increases and thyroxine depressing these factors. In these trials no moisture or crude protein changes in these organs were evident with the exception of a kidney moisture increase in castrate females and a kidney crude protein reduction in castrate males.

The results that have been obtained in these trials, in addition to some of the work reported in the literature, suggests that in the absence of the gonads the effects of the growth depressants and toxic factors appear to be less evident.

Summary

On a 10% ROM grower ration:

(1) Normal female rats had a 25% reduction in weight gain in comparison to castrated females,

(2) In normal and castrate males a 10% reduction in liver and kidney dry matter, an approximate 70% increase in mg. N/gm DM in these organs, a slight reduction in lung weight and a slight increase in thyroid weight occurred in comparison with females,

(3) Castration of either males or females appeared to reduce internal organ weight, especially the thyroid gland.

GENERAL SUMMARY AND CONCLUSIONS

The results are summarized below on the use of ROM as a protein supplement in substitution for soybean oil meal in these rations with 2 species of animals, swine and rats.

Swine Trials

The swine trials were conducted to study the effects and tolerance levels of ROM in swine rations. The levels of Argentine type ROM used were 0, 2 and 10% of the total ration.

The results indicated that in these trials the incorporation of ROM into swine rations resulted in a reduced average daily gain and an increased amount of feed consumption per pound of gain. These effects were usually pronounced at levels of 10% ROM, with little or no effect at the 2% ROM level.

Morphological studies on the swine thyroid glands disclosed close correlation of glandular disturbances with increasing levels of ROM in the swine rations. A consistently marked glandular hypertrophy was evident as levels of ROM were raised to the 10% level. It is suggested that at levels of ROM used in these trials the thyroid gland was attempting to compensate the goitrogenic effects of ROM either through hypertrophy or hyperplastic tendencies.

Swine carcass grades appeared to be unaffected by the levels of ROM used in these trials. A slight trend towards carcass length decrease was evident in pigs consuming the 10% level of ROM.

Figure 8 presents selected metabolism data from both swine and rat trials. In both species, percent food (feed), percent nitrogen, and percent energy digested declined as the level of ROM was increased in the diet. In swine the percent ADN retained fell in the grower rations where the digestibilities were reduced the most; in the other two instances of starter and finisher, it held nearly constant with a slight rise. The ADE/kg ABW declined with the 10% level of ROM on the starter ration. A slight reversal of this trend was evident on the grower and finisher rations. It appears that performance on the starter ration was superior in most cases to the other two rations.

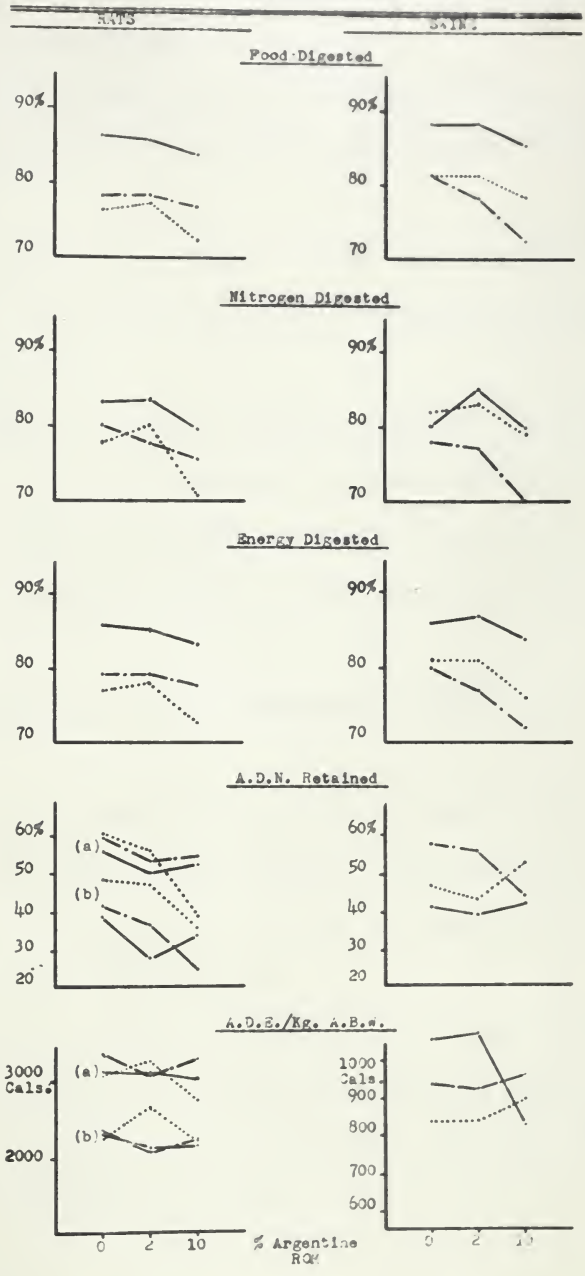
Rat Trials

This phase of the trials was conducted to substantiate data obtained from the swine trials.

Selected data from the metabolism trials conducted using rats are also shown in Figure 8. Percent ADN retained exhibited a decline as the level of ROM was increased. Digestibility results were previously mentioned under swine with the similarity of results being indicated.

ADE/kg ABW results were variable. These results are, as expected, higher than those for swine, due to greater species BMR, however, at this time no detailed explanation is offered for the variable results obtained by the use of rats. It is felt that

Figure 8
The Influence of Rapeseed Oil Meal in the Ration on Selected Metabolism Data



Legend:
(a) = first week trial.
(b) = second week trial.
Starter =
Grower =
Finisher

perhaps this variation might have been due to the variation in thyroidal goitrogenic response exhibited by the rats.

The results suggest that the deleterious effects of ROM upon rats may be enhanced or depressed by the nutritional qualities of a ration.

Radioactive iodine studies on rats show tendencies for thyroid iodine uptake to decline and for thyroid secretion to remain constant as levels of ROM rose.

In a trial conducted to study the effects of castration and sexual differences on ROM tolerance it appeared evident that female rats were more subject to the toxic effects of ROM than were males. Castration of the animals tended to alleviate some of these unfavorable responses.

In conclusion it may be suggested on the basis of these trials that:

(1) The 10% levels of Argentine type ROM, as used in these trials exerted a depressing effect on rate of gain, efficiency of feed utilization and ration digestibility and caused thyroid hypertrophy in both swine and rats,

(2) The 2% levels of ROM did not exert any consistent deleterious effects and in many cases resulted in improved ration performance,

(3) Females, as indicated in the rat trials, were more susceptible to goitrogenic substances in ROM,

(4) Castration of animals, as indicated in the rat trials, may reduce response to ROM toxicity,

(5) The nutritional quality of the ration, as noted in the rat trials, may alter response to ROM toxicity,

(6) To compensate for the goitrogenic effect of ROM and maintain normal body functioning the thyroid gland of the swine and rats appeared to either increase in size or increase the number of cells, with variations noted in individual animals.

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